Greywater Implementation in Montgomery County

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Contents

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Executive Summary

The Montgomery County Parks Department needs to adopt an alternative water source to secure the future of their water supply at their Damascus and Cabin John facilities. A greywater system is a viable option. Greywater is a sustainable, innovative water source collected from sinks and ice shavings for reuse options, conserving water, and reducing energy. Construction and design of these facilities will require new and retrofit strategies. As greywater contributes to a significant percentage of wastewater in public areas, including parks and ice rinks, a proper treatment system is required to remove bacteria and organic compounds. One such system is the Aqua2use Greywater Treatment System, which is a storage and sanitation system that is appropriate for non-potable water reuse and is economically beneficial.

This document provides the blueprints, permits, costs, and the distribution and treatment processes for a greywater system for new and retrofit facilities. Case studies conducted at the Lee Valley facility in England and the Citizen Bank Arena in Ontario, California will aid in determining the design and construction of the greywater ice rink system. Studying the implementation of a greywater system in Spain will help determine the organization of a new or retrofit system. Quantitative assessments of water usage from toilets and ice rinks at the Cabin John facility, accompanied by indirect expense reductions that a greywater system generates, will aid in determining implementation costs. These systems will also comply with the plumbing code of Maryland, EPA's 2012 water reuse guidelines, and the 2011 NSF/ANSI 350 for design, operation, and monitoring requirements.

This paper aims to propose a system that provides alternate reuse options projecting at least a 30 percent reduction in water consumption. This result came from the Rockville 2017 Water Quality Report, which concluded that the use of an alternate toilet-flushing program resulted in a 40 percent decrease in water consumption when using an alternate non-potable water source.

Introduction

The County Department of Parks currently uses best management practices that reduce water consumption in parks, including low-flow toilets and motion sensor water faucets. The County is interested in implementing more best management practices that reduce potable water consumption, including treatment and reuse of ice rink shavings and sink and shower water in the Wheaton and Cabin John ice skating facilities as well as the new Damascus facility to be built.

There is currently no greywater implementation in County parks, but using greywater in restrooms and resurfacing the skating rinks is possible. Ice shavings from resurfacing rinks can contain unsanitary items such as blood, hair, paint chips, mouth guards, and band aids. For this reason, it cannot be reused as greywater before being treated. Our goal is to determine the sanitation process necessary to reuse this water on the ice rinks or for irrigation. One potential use for this water could be in the resurfacing/rink creation process of a new ice sheet. A method for collecting sink and shower water to be reused for toilet flushing will also be investigated.

Within this scope, the following objectives have been prioritized: 1) research applicable greywater treatment and sanitation processes and clarify the components of successful greywater systems implemented by other jurisdictions and how they can be implemented for ice rinks and restrooms; 2) provide tailored recommendations for retrofitting existing and future facilities considered by Montgomery County Department of Parks; 3) determine the permitting process required to implement greywater reuse standards and procedures in restrooms and ice rinks as well as the cost-savings and return on investment of a greywater system.

This report's chapters cover topics researched by the team pertaining to the objectives. Chapters 1 and 2 discuss the technical components of implementing a greywater system, which align with objective one. Chapters 3 and 4 discuss the actual implementation of a greywater system in the freestanding restrooms and the ice rink, which align with objective two. Chapters 5 and 6 discuss the permitting process and cost of implementing and installing a greywater system, which aligns with objective three. The report concludes with final recommendations and remarks regarding the implementation of greywater systems in Montgomery County parks.

Precedent Statement

Environmental Science and Policy students at the University of Maryland researched the implementation of greywater systems during the Fall 2017 semester with the intent of designing such a system for the Montgomery County Department of Parks. This plan was developed under the direction of the Partnership for Action Learning in Sustainability (PALS) program and Professor Rachel Lamb. The information and recommendations included are based primarily on a literature review and case studies. Although the Montgomery Parks system is unique, these cases serve as parallel systems on which to base our design. An ice rink facility that entirely uses greywater does not exist, thus this deliverable serves as a starting point for implementing such a system. This would be the first of its kind, and we are excited to be a part of this process.

Chapter 1: Sanitation Process and Greywater Technologies

Introduction and Overview of Current Water Usage

This project's overall objective is to create a general standardization for the County Parks Department to reuse greywater at the Cabin John and Wheaton ice rinks, as well as a new ice rink that will start construction in 2020. One objective of this study is to collect information about the greywater sanitation process and current greywater treatment technologies. The Parks Department wants to recycle greywater collected from ice rinks, showers, and sinks to be reused in toilets, irrigation, and possibly resurfacing the ice rinks. In two years, the Department has spent more than $90,000 on water bills for the Cabin John ice rink; reusing the greywater for the ice rinks can reduce water costs (Poore, J. personal communication. October 16, 2017). This chapter includes current greywater treatment technologies, a detailed explanation of the greywater sanitation process, and a description of treatment systems suitable for ice rinks and restrooms.

Determining the Current Treatment Process

This paper's main objective is to answer the research question "What are the current available greywater treatment technologies, and which ones are applicable for ice rinks and restrooms facilities?" The approach is to study the basic sanitation process and different types of sanitation processes through literature reviews, then investigate the different types of greywater treatment technologies that are available. Finally, we analyze which technology will be applicable for the ice rinks. The Cabin John ice rink will have two greywater treatment systems, one of which will treat greywater from ice rinks and the other from bathroom facilities. Two separate treatment systems will not be cost efficient, given the expense of connecting the pipelines from the holding tank containing melted ice shavings and the greywater from the restrooms. Some of the restrooms are outside of the ice rink building, which would increase costs of combining the two. There is also a concern that potentially hazardous paint will be in the ice shavings, which increases the need to filter the ice rink shavings. However, after determining if the ice shavings contain paint, future ice rink facilities may be able to combine greywater from the sinks, showers, and rink shavings into one tank, streamlining the treatment process.

Basic Sanitation Process and Available Greywater Treatment Systems

The basic sanitation process collects the raw greywater into a tank, which may contain a mechanical filter or filter pad to separate the solid material from the liquid. The water would then go through biological treatment to remove bacteria, and then through a final filter. The water would be disinfected, and the clean, but non-potable water would be stored in a tank. There are different filtration systems and also different types of disinfection processes. For the filtration system, there are filtration pads, sand filtration, and granular filtration, which uses volcanic tuffs. The two types of disinfection processes are UV disinfection and chlorination.

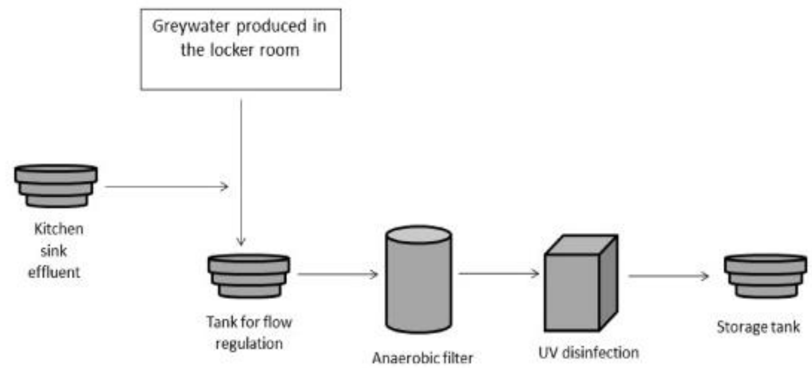

Figure 1.1

Greywater Treatment Unit Couto, E. d., Calijuri, M. L., Assemany, P. P., Santiago, A. F., & Lopes, L. S. (2015).

There are various types of greywater treatment technologies. Different brands of differing system types use different treatment processes. Most of the treatment systems are suitable for domestic use, and good for a small-scale water usage. For the commercial or a large-scale usage, treatment systems with bigger tanks can be located either underground or outside the facilities. Cabin John ice rink has four locker rooms with two showers, one toilet, one sink; men's restrooms with three urinals, three toilets, three sinks; and women's restrooms with six toilets and three sinks. Greywater treatment for these restroom facilities would be suitable from companies like

BioMicrobics and Aqua2use, examples that use greywater treatment systems that meet the permit requirements for the EPA for using treated greywater.

The most popular brands of greywater treatment systems include Aqua2use and BioMicrobics. Aqua2use model GTWS1200 is a commercial sized system that can process about 300 gallons a day. For the Cabin John ice rink, there are three rinks: 200x100ft, 200x85ft, and 90x45ft. They are shaved 24-30 times a day. Their holding tank has 100ft^3 capacity. For this kind of large scale greywater treatment for the ice rinks, Aqua2use will not be sufficient to treat the greywater from these ice rinks. However, for the freestanding bathrooms outside of the building, this Aqua2use model is suitable, as this system is compact (72x72 in) and not as expensive as other brands. This brand will be discussed more in Chapter 3.

BioMicrobics has three models for their greywater treatment systems. Their BioBarrier® MBR (Membrane BioReactor) System uses membrane technology and can process from 375 gallons to 4500 gallons a day, depending on the model. This brand can process higher amounts of greywater, but due to its large size (41ftx12ft), the whole system, excluding the control panels, would have to be planted underground. This would not be recommended for the existing facilities; digging up the concrete and retrofitting to install this system would require closing the facility, and it would not be cost efficient. However, this may be a useful system for a new facility beginning construction.

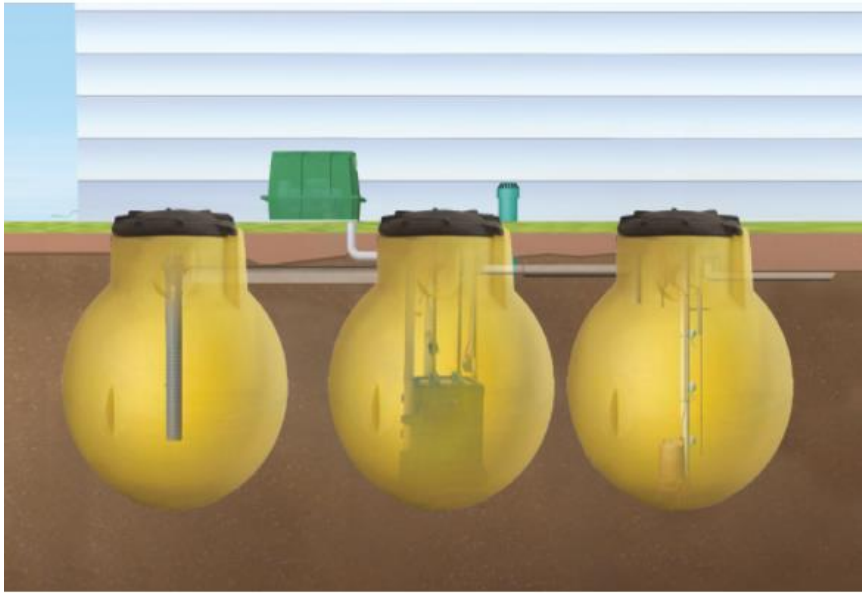

Figure 1.2
BioBarrier Greywater Treatment System.

Chapter 2: Limitations to Reusing Ice Rink Water

Background of Rink Resurfacing

Ice skating rinks are home to several potential reuses of greywater. Most obviously, bathroom sink piping could be restructured to use soapy greywater as water for flushing toilets. A more challenging problem arises when dealing with ice shavings from resurfacing ice rinks. This process adds significant loads of water to waste treatment plants, when in reality, the water could serve several purposes in place of using fresh potable water. One constraint to implementing a greywater system in ice rinks is determining the quality of greywater that is safe for bathroom and rink resurfacing. This study required analysis of acceptable levels of hazardous contaminants for flushing toilets and resurfacing ice rinks, as well as best methods for filtering contaminants to reach a safe level.

Research Method of Ice Shaving Contaminants

It is important to identify the hazardous compounds in ice shavings and how to remove them. The water used on ice rinks is not pure water. It is chemically treated by WSSC, and contains an assortment of paints. Thus, the water needs to be filtered before it's repurposed.

A literature review on the known chemicals in the ice found the primary toxin to be Jet Ice Limited red, blue, and white rink paint, isoctylphenoxypolyethoxyethanol, as identified by the Cabin John Ice Rink staff. The documents produced by Jet Ice Limited provide basic safety information about the compounds' reactivity, toxicological properties, and methods to prevent hazards to human health. While helpful, the fact sheet did not discuss how to remove paint from water, or how the paint may affect nearby irrigated fields if leaked (Material Safety Data Sheet 2003).

Determination of octylphenoxypolyethoxyethanol's impact on the soil surrounding Cabin John was performed. Literature reviewed focused on toxicity to animals, and the residence time in the soil and natural environment. A toxic chemical may hinder grass growth in fields and do more harm to ecosystems than would make greywater use worth it.

A soil survey of the 108 acres surrounding Cabin John Ice Arena was performed to analyze how potent a chemical could be to the local environment. Compact soil is a major indicator for low permeability. This indicates chemicals would easily leach to rivers and streams nearby, proving deadly to aquatic life. Methods of removing octylphenoxypolyethoxyethanol for either irrigation or resurfacing were discussed last.

Health and Environmental Assessment of Octylphenoxypolyethoxyethanol

The literature review determined that Jet Ice Limited ice rink paint can be toxic to both humans and the environment. Human contact can result in eye, skin, or respiratory damage if not treated properly (Material Safety Data Sheet 2003). Octylphenoxypolyethoxyethanol entering the eye causes irritation and must be flushed with water for fifteen minutes. Medical attention must occur immediately. Contact with skin is slightly hazardous, and can result in severe irritation with prolonged exposure (2003). If inhaled, one must move to an area with fresh air and receive oxygen if breathing proves difficult (2003). Information regarding serious skin contact, serious inhalation, or serious ingestion is not currently available.

Chronic health effects are possible as well. Mammalian somatic cells can become mutagenic and potentially result in cancer. Octylphenoxypolyethoxyethanol is a class 4 carcinogen, although there is no evidence to support the cancer-causing properties (Material Safety Data Sheet 2003). The toxins can also cause reproductive and developmental damage in females. Oral doses of 65,500 mg/kg were fed to mice and resulted in cancer and birth defects, but no studies were performed on humans (Material Safety Data Sheet 2003).

Environmental properties of octylphenoxypolyethoxyethanol were also investigated. It is combustible at elevated temperatures and is flammable in the presence of extreme heat. Short term products that result in degradation of the environment have not been studied extensively, however it is possible that long term residence time issues may arise (Montgomery County Government 2017). As the compound degrades, the oxygen and carbon dioxide molecules that construct octylphenoxypolyethoxyethanol are less toxic than the chemical. Other than the effects of octylphenoxypolyethoxyethanol on female mice, no studies regarding environmental impacts have been carried out (Montgomery County Government 2017).

After determining the paint's effects on human and environmental health, methods to remove octylphenoxypolyethoxyethanol were identified. Microdialysis is new way of effectively removing a sample of TX, an industrial form of octylphenoxypolyethoxyethanol, that had not been researched thoroughly before (Opitz et al 2015). Previous means of extracting TX as a precipitate has involved organic solvents and chromatographic separation (Opitz et al 2015). When low concentrations of detergents were present in solution, low amounts of TX were found. But as the amount of TX and other additives present in solution increased, the amount of TX present in the spectroscopy also increased (Opitz et al 2015).

Sludge formation can isolate precipitates, like TX, from water and be filtered out while iron and ferric ions suspend solids in water. Following the addition of these compounds, the authors of one study tested the water for turbidity, chemical oxygen demand (COD), color, and volume of sludge in water. COD removal reached up to 91% from bioflocculation, color removal reached 99% with coagulant and PO (Aboulhassan et al 2007). From the literature review, one of these methods must be used to remove TX from the paint in Cabin John Ice Rink before reusing the water.

Soil and Wildlife Impacts

If water is not used for ice rink resurfacing but rather for irrigation, an assessment of soil structure needs to be completed. Web Soil Survey, a USDA online tool, can provide specific information about soil type and properties for any location in the United States. A 108-acre plot that included Cabin John Ice Rink, forest, and other fields was chosen to see how paint chemicals might impact the nearby landscapes.

Figure 2.1 is a visual representation of the study region. Each separate soil type is designated by a black outlined polygon. Yellow polygons show medium soil compaction, red show high soil compaction, and white show flat urban lands with no soil exposed to the surface. All but the urban surfaces shown in Figure 2.1 and Table 2.1 show that the study region has medium to high soil compaction throughout. The denser the soil, the more runoff that will chemicals and toxins across the land surface without percolating or entering the soil (D'Haene et al 2008). TX can then be found throughout any irrigated field, such as the baseball field labeled 65B in Figure 2.1. This ice rink is approximately seven miles away from the Potomac River and so smaller streams and tributaries of the Potomac can be contaminated easily (Ten-year Comprehensive Water Supply and Sewerage Systems Plan 2017). The land in this region is also highly elevated, with all of it aside from urban land being 3-25% sloped (Soil Survey Staff 2013). Uneven

surfaces speed up the leaching and runoff process due to gravity. One final important soil property is that all soils mentioned are silt loams. Silt loams consist mainly of both silt and clay layers throughout. Silt particles are loosely held together and allow for water to easily enter the soil, while clay is compact. The
combination of these, according to Web Soil Survey staff, make silt loams prime land for farming or fields (2013). Compaction from athletes playing baseball or other sports and large machinery crush the soil, diminishing the mentioned benefits.

Figure 2.1
Soil map of Cabin John Ice Rink.

Map Unit Symbol	Map Unit Name	Slope	Compaction Susceptibility	Acres	% of AOI
1C	Gaila silt loam	8-15%	High	8.4	7.70%
2B	Glenelg silt loam	3-8%	Medium	60.2	55.40%
2C	Glenelg silt loam	8-15%	Medium	4.7	4.40%
54A	Hatboro silt loam	0-3%	Medium	1.8	1.60%
65B	Wheaton silt loam	0-8%	Medium	16	14.70%
116D	Blocktown channery silt loam	15-25%	Medium	0.5	0.50%
400	Urban land	NA	NA	17.1	15.70%

Table 2.1
Soil types and characteristics of Cabin John Ice Rink.

Chapter 3: Components of a Greywater System

Parallel Systems to Cabin John

This chapter evaluates components of the greywater system and its potential reuse in the Cabin John facility. Montgomery County is seeking to implement an innovative technique in potable and non-potable water management that is efficient and appropriate for water reuse. The technique will require retrofitting the existing plumbing infrastructure and fixture systems to collect greywater from sinks and showers to be reused for toilet flushing and landscape irrigation. Further discussion of the greywater treatment system will include the description and operations of two greywater case studies conducted in Doha, Qatar and Mallorca, Spain, as well as a proposal for the adoption of a greywater system for a sustainable approach to potable and non-potable water management.

Research Methods of Existing Greywater Facilities

There are two studies of greywater treatment systems that Montgomery County could use at the Cabin John facility. The first study was conducted at a junior college building in Doha, Qatar in 2015. The system was designed and constructed to incorporate greywater for interior and exterior uses. The greywater was collected from sinks and cycled through an Aqua2use GWTS1200 system, where it subsequently went through a pre-filtering stage using a series of filters to remove large and small particles, treating approximately 300 gallons of water. The water was then transported through two treatment chambers using an ultraviolet disinfectant. The treated water was transported to a holding tank for toilet flushing and landscape irrigation as needed. Water consumption and management was measured to evaluate water-use efficiency, and energy measurements were taken to evaluate energy efficiency over a three-year period.

The second study was conducted in Mallorca, Spain at a hotel with eighty-one rooms and nine floors. The intention was to provide a safe indoor greywater system to flush toilets (March, & Orozco 2004). The reuse system collected water from sinks and sent it through a filtration stage, a sedimentation process, and finally disinfected it with sodium hypochlorite. The treated water was temporarily stored in a ground level tank and pumped to a higher-level tank that was connected to six tanks, diverting the water to the hotel room toilets for flushing. The water temperature operated at approximately 32 degrees Celsius for effective treatment. Water analysis and sampling was conducted on raw and treated greywater to evaluate the quality of the reused greywater and for removal efficiency of the system.

Possible Greywater Implementation

The greywater system in Doha, Qatar using Aqua2use showed an 85% reduction in potable water use from the implementing the system in 2015. The filtered greywater operates as a backup system for landscape irrigation and toilet flushing. The greywater system in Spain used sedimentation, filtration, and disinfection treatment, and functioned for one year without any major problems. The shift in water distribution didn't affect the characteristics of the treated water. Both systems were successful in implementing a greywater system that potentially reduces water consumption and reduces energy use. However, the sedimentation, filtration and disinfection system requires more research into the disinfecting process because the greywater produced in the study area was contaminated with bacteria. The Cabin John facility will undergo a plumbing retrofit that requires separating the sink pipes from the main union pipes (that distributes water to the sewer) and capping each of them. The sink pipe will then attach to another union pipe that connects to a treatment system. The most beneficial system is Aqua2use because it is an appropriate treatment source for removal efficiency and will provide a model for the new Damascus facility (Figure 3.2).

Greywater Retrofit at Cabin John

The greywater in this paper included water from sinks and showers reused for toilet flushing and landscape irrigation (Figure 3.1). The combination of greywater and rainwater was proposed, but study results indicated that adding rainwater introduces very little water saving efficiency. The water treatment system suggested for Montgomery County is the Aqua2use treatment system that uses the necessary components required for bacteria and solid waste removal efficiency.

Information presented in this research suggests that adopting this type of system can provide economic and environmental benefits. However, problems could arise that prevent the its successful implementation, including plumbing retrofitting installation and cost and acceptance from society, along with other unknowns that could develop into major concerns.

Implementing a greywater system at Cabin John will significantly decrease water demand and serve as a pilot system for Montgomery County in the reuse of natural resources.

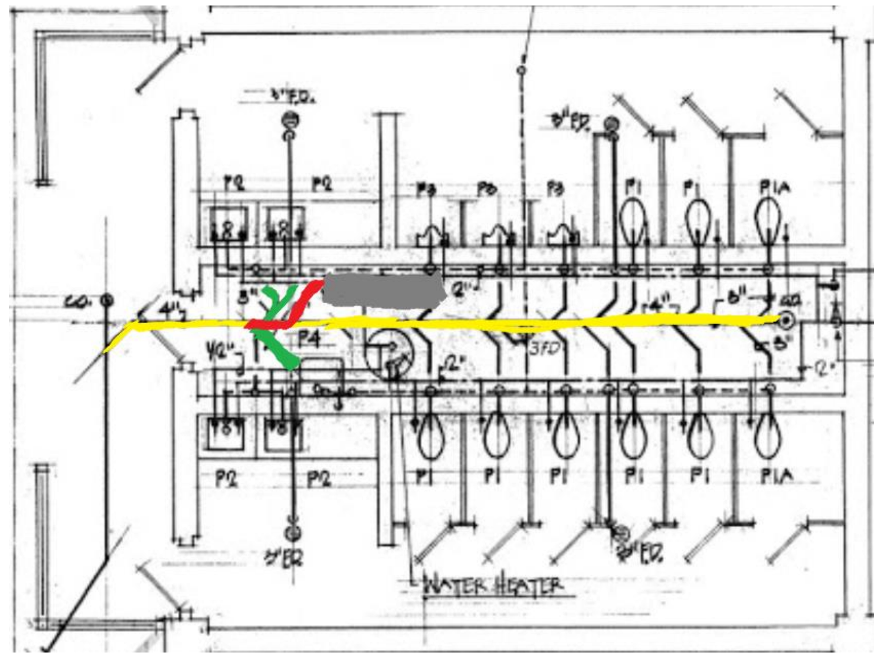

Figure 3.1
Aqua2use greywater treatment system (GWTS1200) working principle on how it reuses greywater for toilet flushing and landscape irrigation (Aqua2use Greywater Treatment System 2010).

Figure 3.2
Current Blueprint for Cabin John Standard Bathroom. The sinks pipes (green) should be separated from the main pipes (yellow) and connected to another union pipe (red) that connects to the Aqua2use system (grey).

Chapter 4: Greywater Ice Rinks

Overview of Ice Rink Shavings

Each layer of ice that is shaved off the ice rinks can be reused in different ways before being sent into the sewer system; for example, they can be reused in resurfacing. Reusing the ice shavings would help reduce the amount of freshwater used on the ice every day. This would be sustainable and possibly save money in water costs.

Existing Greywater Ice Rink Facilities

To look at how the Department of Parks would implement a greywater system, a case study was conducted on how other facilities have reused ice shavings. Ontario, California has a functioning recycled ice rink. However, they don't use the ice shavings to re-surface; they have a stormwater capture facility used to re-surface. In this facility, the ice rink includes a portion of recycled rainwater. Even though Ontario does not use the ice shavings, they do have a recycled ice rink, so it is possible to build a greywater ice rink. Another facility that reuses ice shavings is the Lee Valley White Water Centre in Hertfordshire, England. In this system, the Zamboni shaves the ice off the rink and dumps the shavings into a hot well heated from waste heat of the refrigeration plant. The ice shavings melt and the liquid is easier to transport and filter. The melted ice is pumped through strainers and a UV filter into a roof-top holding tank. This water in toilets and urinals. The holding tank can be supplemented by clean, potable water if the ice shavings are insufficient in filling the toilets and urinals. Although Lee Valley does not use their ice shavings to re-surface the rinks, their process of capturing the ice shavings and treating the ice shavings can be implemented in the Montgomery Parks facilities for possible reuse in irrigation, bathrooms, and possibly on the ice rink itself.

Retrofitting Cabin John for Greywater Use

Cabin John presents some issues because the facility is in place and the building has a lot of concrete. To reuse the ice shavings in either the ice rink or the toilets, the holding tank could not be placed on the roof as in Lee Valley, but instead in an annex to the side of the where the Zamboni machines are kept, as seen in Figure 4.1. A building 25 feet by 25 feet would need to be built where the blue X is located in the blueprint in Figure 4.1. That location is next to where the Zambonis are located and where the current holding tank is. In addition, there is space there to build. Since it would be near the current holding tank, constructing and piping is easier than if the building were farther away. The annex would house a holding tank slightly larger than the current holding tank.

The process for capturing ice shavings would work as follows: the Zamboni would shave off the top layer ice, and dump the shavings into the current holding tank. From there, the melted shavings would be pumped through a strainer and filters to remove any frozen items such as hair ties, mouth guards, etc. Then the melted ice would be dumped into the new holding tank in the annex. That holding tank would have a heated rotating component to keep the melted ice from refreezing and to keep Legionella bacteria from forming. The water could then be pumped directly to the Aqua2use systems for the toilets and urinals. The facility does have a lot of concrete so this system would require a substantial amount of construction. But once the water is in the holding tank, and the piping infrastructure is in place, the toilets could use greywater. Any excess ice melt not used in the toilets could either be treated for irrigation or dumped into the sewer. Building an annex and leaving the current clean water toilet system in place, creates a backup if ice shavings are insufficient or if there is an issue with the shavings. In case of a malfunction, the facility could turn a valve and return to using potable water in the toilets and urinals.

The process to reuse the shaved ice on the rinks is similar to using the greywater in toilets. Pumping the water from one holding tank to a second holding tank is the same except that the catchment filter would be placed under the grate that is over the current holding tank. This would ensure easy maintenance. The catchment filter would be either mesh or metal and need to be checked and cleaned regularly. This filter would remove any items frozen into the ice so it needs to be sturdy with small gaps. There is not much information about the risks associated with reusing ice shavings for resurfacing. The quality and integrity of the water may decrease after each shaving. In addition, there may be freezing issues if the water quality is poor. There are also unknown health issues with using greywater. We were unable to test the ice shavings so we do not know for sure what is in the ice melt. Further testing on the ice melt is required before using it for resurfacing. If it is deemed safe to reuse the ice melt without any further filtration system, then the Zamboni can draw water directly from the second holding tank in the annex building.

If there is a need for more filtration, an ultraviolet filtration system can be implemented. The Aqua2use system outlined in Chapter 3 will help purify the water. This UV system is similar to the one used by Lee Valley. The systems would be built in the annex building where the second holding tank would be located, which means that the annex building may have to be a little larger. The ice melt would be pumped from the existing holding tank in the Cabin John facility to the Aqua2use systems in the annex. The filtration system would then clean the water and deposit the filtered ice melt into the holding tank. Once the melted shavings are in the second holding tank, a nozzle and pipe would be placed on the tank’s side to transfer the water from the second holding tank to the room where the Zambonis are held. When preparing to re-ice the rinks, the Zamboni would be filled with 50% greywater and 50% fresh, potable water. This is not a perfect estimate and trials should be conducted to discover the correct mixture of greywater and freshwater. Re-icing cannot be 100% greywater because the shaving and dumping process does not recapture 100% of the ice. In addition, the integrity and quality of the water is compromised when going through the icing, shaving, and filtration process. Mixing the greywater with potable water will could mitigate some of these issues.

Issues with Greywater for Resurfacing

As mentioned earlier, there are no ice rinks that reuse ice shavings for resurfacing and so there isn’t much data about the quality of ice melt. Furthermore, there are no previous examples on which to base a facility. Another issue is the filtration system. The Aqua2use systems can only filter so much water per day. Chapter 3 and Chapter 6 go further into detail about the systems but the amount of ice shavings more than one Aqua2use system can purify. This means that if Montgomery Parks wants to build a greywater ice rink, more than one Aqua2use systems would be required. Multiple systems require more intense infrastructure and have a higher risk of malfunction. It is possible to create a test rink and use one or two filtration systems to purify enough ice melt to test. By creating a smaller test project, Montgomery Parks can see if the benefit is strong enough to implement greywater ice rinks on a large scale.

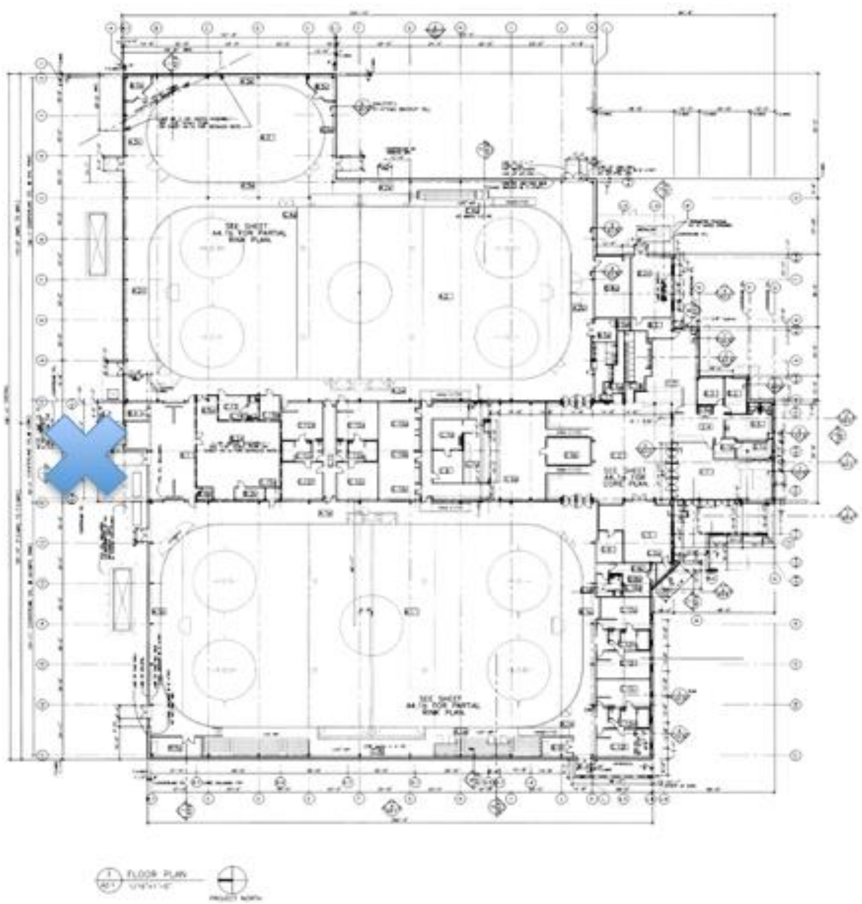

Figure 4.1
Current Blueprint for Cabin John Facility with Blue X for projected new building.

Chapter 5: Permitting and Regulations

Introduction and Overview of the Permitting Process

The regulations for greywater systems fall under federal, state, and local government agencies, all of which address the implementation of greywater systems via policies and permits. This study initially reviewed literature to find relevant state and county building and plumbing codes. After reviewing the 2013 Plumbing & Fuel Gas Code provided by the Washington Suburban Sanitary Commission, the federal quality standards were reviewed, as provided in the Environmental Protection Agency's 2012 Guidelines for Water Reuse. Although some states have their own greywater system standards, Maryland does not. The County Parks Department must rely on the WSSC to set the permitting process, which in turn relies on federal water quality standards. There is also no federal standard for greywater in place. Rather, the standards set by the NSF and the EPA are meant as suggested regulatory guidelines for water re-use opportunities. A NPDES permit will not be necessary in this case for plumbing, ice rink resurfacing, or irrigation systems, barring any surface water discharge. The current permitting process would begin with the Parks staff having a certified engineer draft a plumbing plan and submitting it with a Long Form Permit Application to WSSC. Upon approval, construction can begin. Federal guidelines denote the water quality standards once the system is in place.

Researching the Permitting and Regulatory Process

To determine local codes pertinent to implementing a greywater system in Montgomery County Parks, Tom Buckley, WSSC Planning and Cross Connection Section Manager provided the 2013 WSSC Plumbing & Fuel Gas Code. This document pertains to greywater used in restrooms and re-icing rinks at new and existing facilities.

The Maryland Department of the Environment's Wastewater Permits Program was reviewed to determine the state and local permits required to use treated greywater for irrigation. The MDE's Guidelines for Use of Class IV Reclaimed Water was reviewed to determine if a discharge permit is required to transport the treated water to an underground cistern used in stormwater storage, as well as any stipulations on the area of use. Federal regulations involving the discharge of greywater from the ice rink to a stormwater cistern for irrigation was investigated by contacting Ginny L. Davis, Public Information Center Specialist from the US EPA, as well as reviewing the National Pollutant Discharge System (NPDES) guidelines.

To determine the water quality standards greywater systems must adhere to, including toilet flushing, irrigation, and ice rink resurfacing, the EPA's 2012 Guidelines for Water Reuse was reviewed. This document contains both the EPA standards, as well as the NSF/ANSI 350-1 regulations for water quality.

State and Local Permitting

The permitting and regulatory process for using greywater in restrooms and ice rinks falls under state and federal policies. Maryland does not have state-wide regulations for greywater systems. Instead, the state defers to local plumbing codes for water re-use systems ("Wastewater Permits Program" 2017). In Montgomery County, the WSSC governs retrofitting and new construction plumbing projects requiring access to the sewer system. A permit must be acquired before any construction begins. A long form permit is submitted to WSSC and must be completed by a registered plumber and accompanied by design plans. This is done through the e-permitting system on WSSC's website under non-residential replacement fixtures for retrofitting cases. This application is available under non-residential new construction for new park fixtures (*2013 WSSC Plumbing & Fuel Gas Code* 2013). The applicable subsections are listed in Table 5.1.

Federal Water Regulations

As noted in Chapter 9 of the WSSC plumbing code, water quality standards are set by the EPA for states without their own set of standards. The 2012 EPA Guidelines for Water Reuse include both the standards set by the EPA and the NSF/ANSI 350-1 regulations. The NSF/ANSI standard 350-1 for greywater notes that a greywater system should be performance tested for six months on site. The system can be monitored remotely after it is in place. The standards set by the NSF are not federally required, though adherence to these standards can gain a site up to 10 points in LEED certification in the water efficiency category (*2012 Guidelines for Water Reuse* 2012). NSF/ANSI Standard 350-1 standards are available in Table 5.2.

The greywater from ice shavings that could potentially be used for irrigation purposes is not regulated by WSSC because it doesn't require sewer access. The water will go from a filtration system to an underground cistern without mixing with surface waters.

Since NPDES permits are written for discharges to surface waters, there's no regulation or guidance under NPDES for reuse of wastewater. If there is a wastewater treatment plant discharge that proposes to reuse the effluent, it would normally be treated to whatever standard needed to protect the surface water since there would most likely still be some of the effluent discharging to the surface water. If 100% of the effluent is being reused and there is no surface water discharge, as in the proposed system, no NPDES permit is required (Davis 2017).

The MDE notes that if the non-potable water is produced and treated on-site and used for incidental irrigation with a 25-foot buffer between the park and neighboring property, a discharge permit can be applied for, which would exclude the system from the requirements of MDE's reclaimed water guidelines (*Guidelines for Use of Class IV Reclaimed Water: High Potential for Human Contact* 2016). For water not covered by a discharge permit, the EPA has suggested regulatory guidelines for water re-use opportunities in states like Maryland that haven't developed their own criteria ("Permits" 2017). These guidelines are in Table 5.3.

Based on the literature review, the following tables contain pertinent codes and regulations.

Chapter 9		
Section Title	Subsection	Description
901.3- General Definitions	4.2	Graywater system: A decentralized water re-use system that employs on-site treatment of the discharge from specific plumbing fixtures such as bathtubs, showers, lavatory sinks, clothes washers, laundry tubs/trays, etc. thereby producing recycled water for various specific non-potable uses.
902.1- Permit Requirements	1.3	Use Within the Building: Any utilization of non-potable water within the building, including but not limited to, toilet and urinal flushing; mechanical system make-up; equipment cooling; etc.
904.1- General System Design	1.1	Construction Documents: Design plans shall include plan views, including exterior tanks and associated piping, complete elevation schematics, and corresponding equipment schedules. Zoom and scale shall be adequately enlarged to facilitate a clear understanding of all equipment, appurtenances and flow direction.
904.5- Minimum Water Quality Standard		It is the responsibility of the appropriate State and County Government Agencies to establish water quality standards. At a minimum, non-potable water produced for plumbing, mechanical and industrial process as allowed by this Code, shall meet the parameters set forth by the Maryland Department of the Environment – Class IV effluent water quality standard, or other equivalent standards established by local authorities.
904.6- Piping	1	Graywater Collection Piping. Graywater collection piping systems and associated collection reservoirs/sumps shall be protected from the sanitary sewer system by segregation, an air gap or a backwater valve.
905.3- Disclosure and Signage		Water Re-use Equipment Room. In all water re-use equipment rooms there shall be a disclosure sign, or signs as needed. Each sign provided shall have highly visible lettering a minimum of a ½" in height on a contrasting background with the following text: "This building utilizes a water re-use system that produces non-potable water for [describe use]. Prior to commencing any plumbing or mechanical work on premises, by law you must consult with the system operator."

Table 5.1

Subsection of Chapter 9 of the 2013 WSSC Plumbing & Fuel Gas Code.

	Class R		Class C	
Parameter	Test Average	Single Sample Maximum	Test Average	Single Sample Maximum
$CBOD_5$ (mg/L)	10	25	10	25
TSS (mg/L)	10	30	10	30
Turbidity (NTU)	5	10	2	5
E. coli[2] (MPN/100 mL)	14	240	2.2	200
pH (SU)	6.0 - 9.0	NA[1]	6.0 - 9.0	NA
Storage vessel disinfection (mg/L)[3]	≥ 0.5 - ≤ 2.5	NA	≥ 0.5 - ≤ 2.5	NA
Color	MR[4]	NA	MR	NA
Odor	Nonoffensive	NA	Nonoffensive	NA
Oily film and foam	Nondetectable	Nondetectable	Nondetectable	Nondetectable
Energy consumption	MR	NA	MR	NA

[1] NA: not applicable

[2] Calculated as geometric mean

[3] As total chlorine; other disinfectants can be used

[4] MR: Measured reported only

Table 5.2
NSF/ANSI Standard 350-1.

Resuse Category and Description	Treatment	Reclaimed Water Quality	Reclaimed Water Monitoring
Urban Reuse			
Unrestricted: the use of reclaimed water in nonpotable applications in municipal settings where public access is not restricted	Secondary Filtration Disinfection	pH: 6.0-9.0 10 mg/l BOD 2 NTU No detectable fecal coliform /100 ml 1 mg/l Cl_2 residual (min.)	pH: weekly BOD: weekly Turbidity: continuous Fecal coliform: daily Cl_2 residual: continuous

Table 5.3
2012 EPA Guidelines for Water Reuse.

Chapter 6: Cost of Implementation

Introduction to Determining Cost-savings and Return on Investment of a Greywater System

This chapter offers a quantitative assessment to calculate the cost-savings a greywater system will bring to the new Damascus ice rink by observing current water usage costs at the Cabin John ice rink. The final result will establish the return on investment of a greywater system. This will be determined by examining greywater implementation costs-savings through algebraic equations based on current water usage at Cabin John with ice rink shavings and restroom facilities as variables. In addition, a literature review will consider indirect savings generated by a greywater system from environmental and social savings and benefits. The expectation is to present the cost-savings of implementing a greywater system that will generate a return on investment in a number of years. Although it is an investment to buy a greywater system, the monetary, environmental, and social benefits it will provide to the County will far exceed the upfront costs. Annually, Department of Parks can save an average of $4,201.36 in water costs at the new Damascus facility by installing two Aqua2use model GTWS1200 greywater systems, one for the ice rink and one for the bathroom facilities. The return on investment for buying each greywater system is 5.66 years. These numbers are significant; as more greywater systems are bought, the more savings the County will see each year.

How to Calculate the Cost-savings and Return on Investment of a Greywater System through a Quantitative Assessment

The algebraic equations used in Table 6.1 were initially inspired by an empirical study that looked at the cost-savings greywater systems bring to commercial facilities (Memon et al 2005). Similar variables to the ones expressed in the methods section of this chapter were used, however, the variables were altered to be specific to the Cabin John facility, rather than a large commercial facility. The equations were derived by starting at the cost-savings resulting from the use of a greywater system and the return on investment of buying a system.

To find out how much the reused water could save the County, it is assumed a greywater system can run with total efficiency, to manage the average or minimum water used each day in the Cabin John facility, 6.84 Kgal (W_d). This amount of water should be more than the amount of water a greywater system can cycle each day (G), assuming the number of systems purchased (N) is sufficiently few, which is shown in Equation (1).

$$W_d > N*G \quad (1)$$

The savings from a greywater system (S) can be calculated using readily available information, such as the number of greywater systems to be purchased (N), the amount of water a greywater system can cycle each day (G), the days per year the Cabin John facility is open (D), and the average cost per Kgal of water bought from the water utility company (C_{Kgal}); all information found on a Cabin John water bill, shown in Equation (2).

$$S = N*G*D*C_{Kgal} \quad (2)$$

Once the savings have been calculated, the initial cost of implementing a greywater system (C_{init}) must be determined, as shown in Equation (3). The price of a greywater system (C_{GS}) is known, but must be multiplied by the number of systems to be purchased (N).

$$C_{init} = N*C_{GS} \quad (3)$$

The time for a return on investment in years (T_{ret}) is calculated, defined by the amount of time it will take the savings to meet the initial cost, as expressed in Equation (4).

$$T_{ret} = C_{init} / S \quad (4)$$

The cost to install and setup the greywater systems (C_{setup}) and the cost of annual maintenance (C_{ma}) cannot be estimated at the current time. Equation (5) is noted so that these costs can be accounted for in future years, which will impact the years it will take to see a return on investment of the systems (T_{ret}).

$$T_{ret} = (C_{init} + C_{setup})/(S - C_{ma}) \quad (5)$$

Table 6.1

A quantitative assessment to determine the cost-savings and return on investment of a greywater system.

Variable	Representation	Value, if known
C_{Kgal}	=average cost per Kgal of water from the utility company	$19.29
G	=greywater system output/day	0.30 Kgal
C_{GS}	=cost per greywater filtration system	$11,900.00
S	=annual savings from greywater usage in years	-
T_{ret}	=time for return on investment in years	-
C_{ma}	=cost of annual maintenance to greywater system	(!)
C_{setup}	=cost to install and setup the greywater system	(!)
C_{init}	=initial cost of implementing the greywater system	-
N	=number of greywater systems	2
D	=days of the year	363
W_d	=average or minimum water used each day	6.84 Kgal

Number	Equation
1	Given: $W_d > N*G$
2	$S = N*G*D*C_{Kgal}$ [dollars/year]
3	$C_{init} = N*C_{GS}$ [dollars]
4	$T_{ret} = C_{init} / S$ (years)(!!)
5	If C_{setup} and C_{ma} are significant, then $T_{ret} = (C_{init} + C_{setup})/(S - C_{ma})$

(!) This value cannot be estimated at the current time, but can be factored in once known.

(!!) Then, the investment will be returned at approximately the same time regardless of the number of systems purchased, provided the systems are all operating at capacity.
$T_{ret} = G*D*C_{Kgal} / C_{GS}$

1) Given: $W_d > N*G$

$6.84\text{ Kgal} > 2*0.30\text{ Kgal}$

$6.84\text{ Kgal} > 0.60\text{ Kgal}$

2) $S = N*G*D*C_{Kgal}$ [dollars/year]

$S = 2*0.30\text{ Kgal}*363*\$19.29$

$S = \$4,201.36$

3) $C_{init} = N*C_{GS}$ [dollars]

$C_{init} = 2*\$11,900.00$

$C_{init} = \$23,800.00$

4) $T_{ret} = C_{init} / S$ [years](!!)

$T_{ret} = \$23,800.00/\$4,201.36$

$T_{ret} = 5.66$ years

5) $T_{ret} = (C_{init} + C_{setup})/(S - C_{ma})$

Explanation of the Quantitative Assessment

The rinks and bathrooms in Cabin John facility use water that can potentially be recycled into greywater by the shavings and flushings of all bathroom appliances. Corresponding to the assigned numbers of the equations listed in Table 6.1: (1) this total amount, the possible greywater, will presumably always be very large, as the average amount of water used daily is 6.86 Kgal (James Poore, personal communication, October 13, 2017). One Aqua2use model GTWS1200 greywater system has a capacity, or output, of 300 gallons per day, or 0.30 Kgal (Greywater Action 2017). As long as the greywater produced is greater than the greywater system can hold, it can be assumed that the greywater system is working at maximum capacity. It is also assumed that all water produced by the greywater system will be reused immediately for the rinks or bathrooms.

As more systems are bought, there may be a worry of whether the systems can be used to maximum efficiency. For example, if there are three greywater systems just for the ice shavings pit, and if the pit is only filled once per day, then, since the pit can hold 750 gallons (0.75 Kgal), that is how much greywater will be produced, and not the maximum 0.90 Kgal (3 * 0.30 Kgal) that the three greywater systems can filter (James Poore, personal communication, October 13, 2017). Therefore, we assume the Damascus facility will produce more greywater than each system can treat daily. This assumption is made because the average amount of water used every day in Cabin John is 6.86 Kgal while a single Aqua2use greywater system can only treat 0.30 Kgal per day. This amount of 6.86 Kgal of water is so high that even at capacity, multiple systems should not come close to treating the water produced by the ice rinks and bathrooms (James Poore, personal communication, October 13, 2017). Thus, the annual savings at the new facility is simply the number of systems * 0.30 Kgal * 363 days a year * the cost per Kgal of water (Jason Schoenfeld, personal communication, October 13, 2017). Cabin John is open 363 days of the year (closed on Christmas Day and Thanksgiving) (Montgomery Parks 2017).

The cost of a typical commercial-sized Aqua2use greywater system is $11,900.00 (Greywater Action 2017). The average cost of water used every day at Cabin John was determined to be $18.11/Kgal. However, the cost of the rate of water every year is slowly increasing. Therefore, the most recent water cost for Cabin John has been the water/Kgal value, which is $19.29/Kgal (James Poore, personal communication, October 13, 2017). (2) If two greywater systems are purchased, one for the bathroom facilities (for sink, toilet, urinal, and shower water) and one for the ice rink shavings, the annual savings will amount to roughly 2 systems * 0.30 Kgal * 363 days of the year * $19.29 = $4,201.36 per year. (3) The installation costs for two greywater systems amounts to 2 * $11,900.00 = $23,800.00. (4) Thus, the systems will pay for themselves in $23,800.00/$4,201.36 = 5.66 years (Jason Schoenfeld, personal communication, October 13, 2017). Not accounting for maintenance and setup costs, it will take 5.66 years to see a return on investment on each greywater system.

Indirect Savings and Benefits Brought by Greywater Systems

Implementing a greywater system clearly brings many direct financial savings to Montgomery County. Along with the financial cost-savings, other potential savings and benefits are environmental and social. From an environmental savings standpoint, by using greywater in Damascus, the local community water system will benefit. There will be a relieved stress on water resources, as groundwater and reservoirs can recharge their water supplies more quickly as a result of lower water withdrawals from local rivers due to the decreased dependency on potable water. In addition to reducing the pressure on local water systems, Montgomery County will save money on energy costs by reducing the energy used to transport wastewater to a treatment facility. By treating water in-house with a greywater system, water can be piped from the shower straight to the toilet to meet flushing needs without having to be transported all the way to a treatment facility (Munoz 2006). This not only saves the County money on energy costs, but it also reduces its carbon footprint. With reduced energy consumption in the Damascus facility, less carbon emissions are released into the atmosphere which in return reduces its carbon footprint. Fewer carbon emissions also equates to improved air quality in the area surrounding the ice rink (Adeyeye 2013).

A concern of park's staff is the public's perception of greywater, and whether implementing a greywater system will affect the Damascus ice rink's use. A greywater system is a positive addition to the Montgomery County community, as it brings many social benefits including providing the community with aesthetic improvements on-site due to increased green space. With more streamflow and water in the local system around the Damascus facility due to less pumping of potable water, more grass, trees, shrubs, or other vegetation can flourish. Not only does improved green space enhance the Damascus facility, but it can also increase or enhance local recreational opportunities outside the building (NASEM 2016). Added local green space and an improved local riparian systems from decreased pumping of water allows Montgomery County to add a park, community garden, playground, public seating area, or public plaza outside the Damascus facility (EPA 2017). Another social benefit is increased public education from using local resources and encouraging sustainability. The Damascus ice rink will be a community center for the County; Park staff can educate the public on the importance of recycling water and using sustainable practices at the facility by explaining what greywater is and how the system functions. Through this education, the public can become more aware of where their water comes from and the benefits of using recycled water (NASEM 2016).

Chapter 7: Final Recommendations and Remarks

This final recommendation describes the greywater systems that can be implemented at the Cabin John and Wheaton ice rink facilities, as well as at the new ice rink in Damascus.

At Cabin John and Wheaton, we recommend using the ice shavings for irrigation rather than resurfacing the rinks or toilet flushing. This is largely due to the cost and feasibility of retrofitting these facilities. The amount of concrete at these locations is extensive, increasing the cost of construction. Removing concrete floors and walls would require the facility to close during the retrofitting process, further increasing costs. Treating ice shavings would require building a large annex to house the treatment and storage apparatus, as well as retrofitting all existing plumbing. Irrigation would require the least amount of construction, and the greywater treatment of can be done with stormwater in the underground cisterns, the most cost-effective treatment method.

Before reusing water that may contain paint, however, a water quality test of shaved ice must be completed. Several water quality tests were researched, but no labs for ocytylphonoxylpolyethoxythanol were identified as feasible over the course of the study period. If it is found that the water is not free of this compound, then an implementable method of extraction needs to exist. From the literature available, two main methods of ocytylphonoxylpolyethoxythanol removal were identified, microdialysis and sludge formation, though these will be difficult to implement on a large scale. WSSC has also voiced some health concerns regarding using greywater to resurface the ice rinks, due to the easy spread of contamination through dermal, eye, and mouth contact, as well as high humidity and constant inhalation on the ice rinks.

The free-standing restroom facilities throughout Montgomery County Parks should be implemented with a filtration system to use sink water for toilet flushing. This would require adding a filter, such as the Aqua2use, to existing plumbing in the corridor between the men's and women's restrooms. This is a relatively easy process that requires little construction and is both cost-effective and environmentally beneficial.

At the new facility in Damascus, we recommend capturing greywater from ice shavings and restroom sinks to be used for toilet flushing.

Installing two Aqua2use greywater systems in the new Damascus facility will save the County money in the long-term, as the annual savings is $4,201.36. The return on investment of each greywater system purchased is 5.66 years. The quantitative assessment shows that the amount of time it will take to see a return on investment is independent of the number of greywater systems implemented, if each system can run at or near maximum capacity. Therefore, the facility will be able to save more money annually with each system purchased. It is also important to note that because the greywater savings come directly from the cost of water, savings will increase proportionally with any change in the price of water from the utility company. If many systems can be purchased and run optimally, long-term savings increase directly. In an extreme example, ten systems are still half the approximate daily water usage, and would reliably be able to provide as much as $21,000.00 in savings annually combined from the use of ten systems.

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